US EPA Mid-Continent Ecology Division

Research Project Summary

Habitat Linkages (Coastal Wetlands and Adjacent Lakes) via Otolith Elemental Fingerprinting

Overview

Fish otoliths are paired calcified structures used for hearing and balance in all bony fishes. Each fish contains three pairs of otoliths called the sagittae, lapilli, and asteriscii (Fig. 1). They reside alongside the brain and vestibular apparatus. Otoliths grow continuously throughout the life of a fish. Similar to what has been observed in trees, daily and annual rings that form on the otolith reflect growth rates of the fish during particular times in its life. Rates can be determined by counting and measuring the rings (Fig. 2). Otoliths are primarily composed of a calcium-carbonate matrix, but also contain a small amount of protein and a variety of trace elements. Thirty-one different elements have been detected in marine and freshwater fish otoliths to date. Elemental composition of fish otoliths reflects the environmental conditions under which a fish was reared, so otolith geochemistry can record differences in ambient water conditions specific to habitats used during a fish's life. Since otoliths are acellular and metabolically inert, no resorption or alteration of the trace elements occurs once they are incorporated into the otolith's structural matrix.

Although few studies have been conducted in freshwaters, trace element analysis of marine fish otoliths has proven useful in identifying chemical signatures unique to particular spawning and nursery habitats. We are examining its utility in freshwater by analyzing sagittal otoliths from young-of-the-year yellow perch (Fig. 3) captured from wetlands in western Lake Superior (Fig. 4). By analyzing the otoliths for a variety of minor and trace elements (e.g. strontium, manganese, potassium, and barium) using mass spectrometry techniques called ICP-MS and ICP-AES, we've found that many of the element concentrations differed significantly among fish captured from the wetlands we sampled. This has allowed us develop relatively distinct fingerprints (differences in the relative abundance of different trace elements among sites) for many of the wetlands (Fig. 5). Using these fingerprints, we can predict the wetland a fish used as a nursery area with about 75% accuracy. We have also found that adult perch captured from wetland and nearshore habitats have very different strontium concentrations in pieces of otoliths milled (Fig. 6) from the most recent growth regions of their otoliths. This allows us to predict the habitat an adult fish came from with 100% accuracy based only on its otolith strontium levels (Fig. 7). Our results suggest that wetland and nearshore fingerprints derived from otolith elemental analysis should be useful for quantifying relative contributions of different nursery areas to the recruitment of fish in adjacent open lake populations, and for determining the relative importance of different habitats types to fish in the Great Lakes.

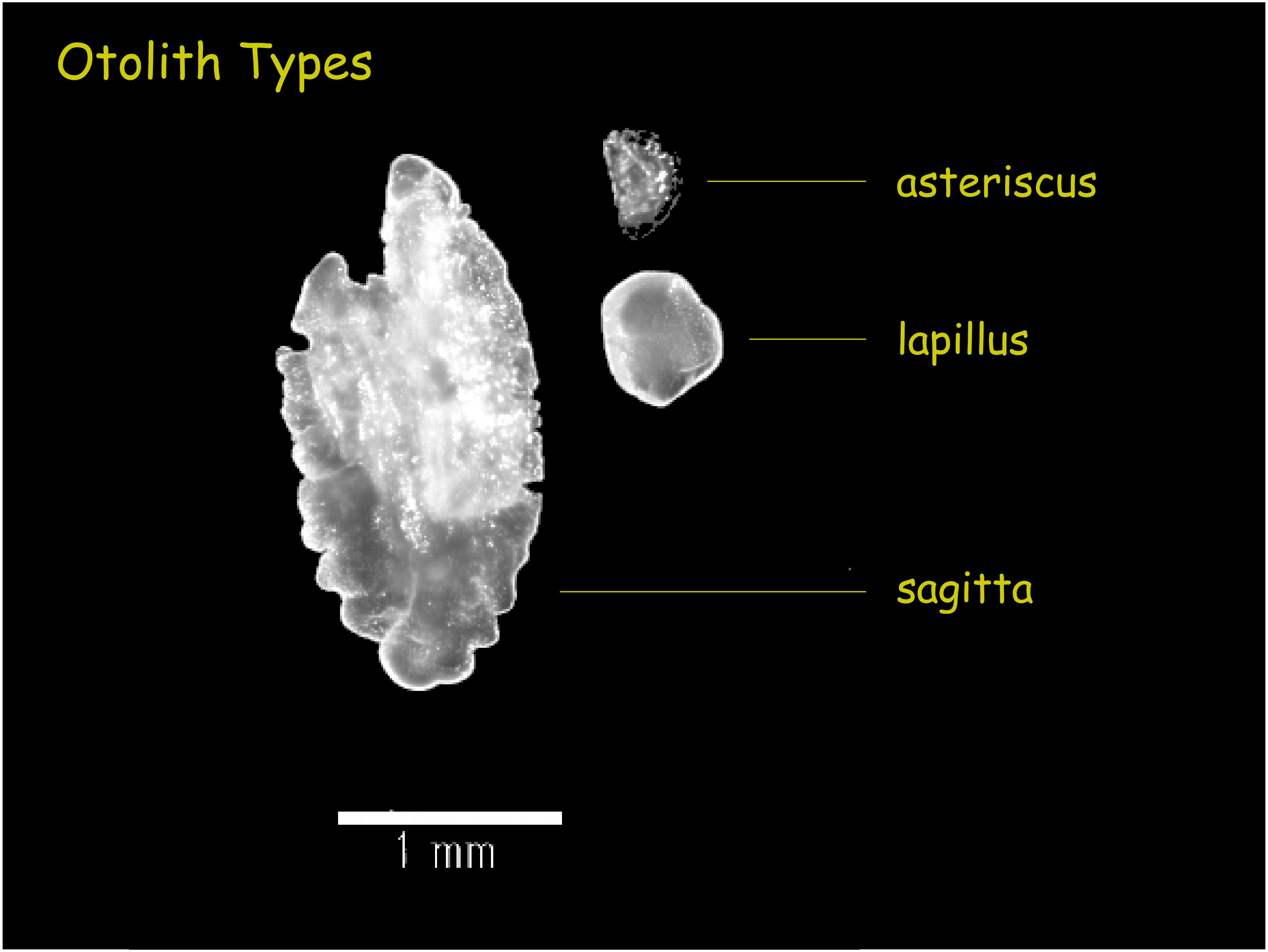


Figure 1

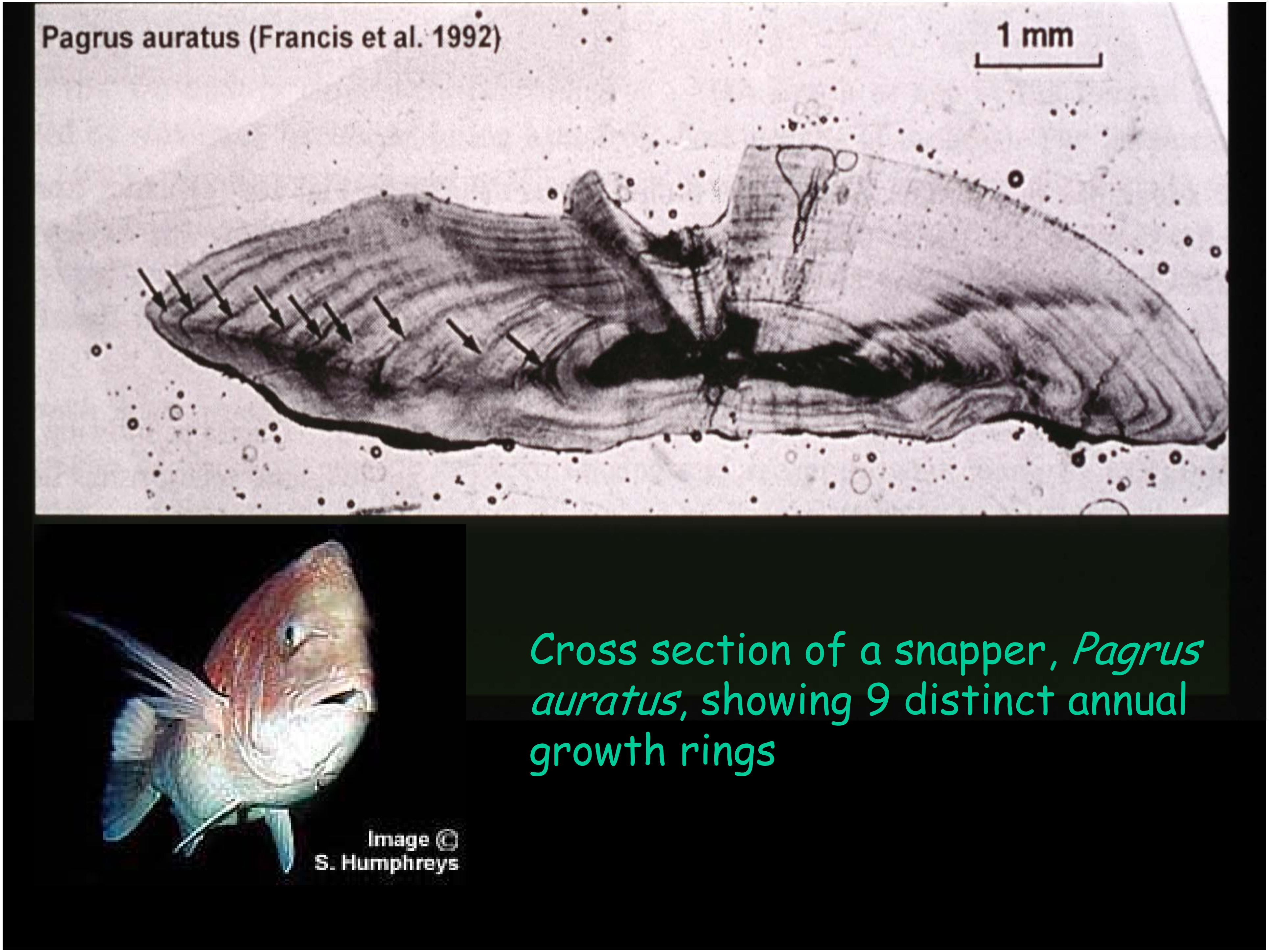
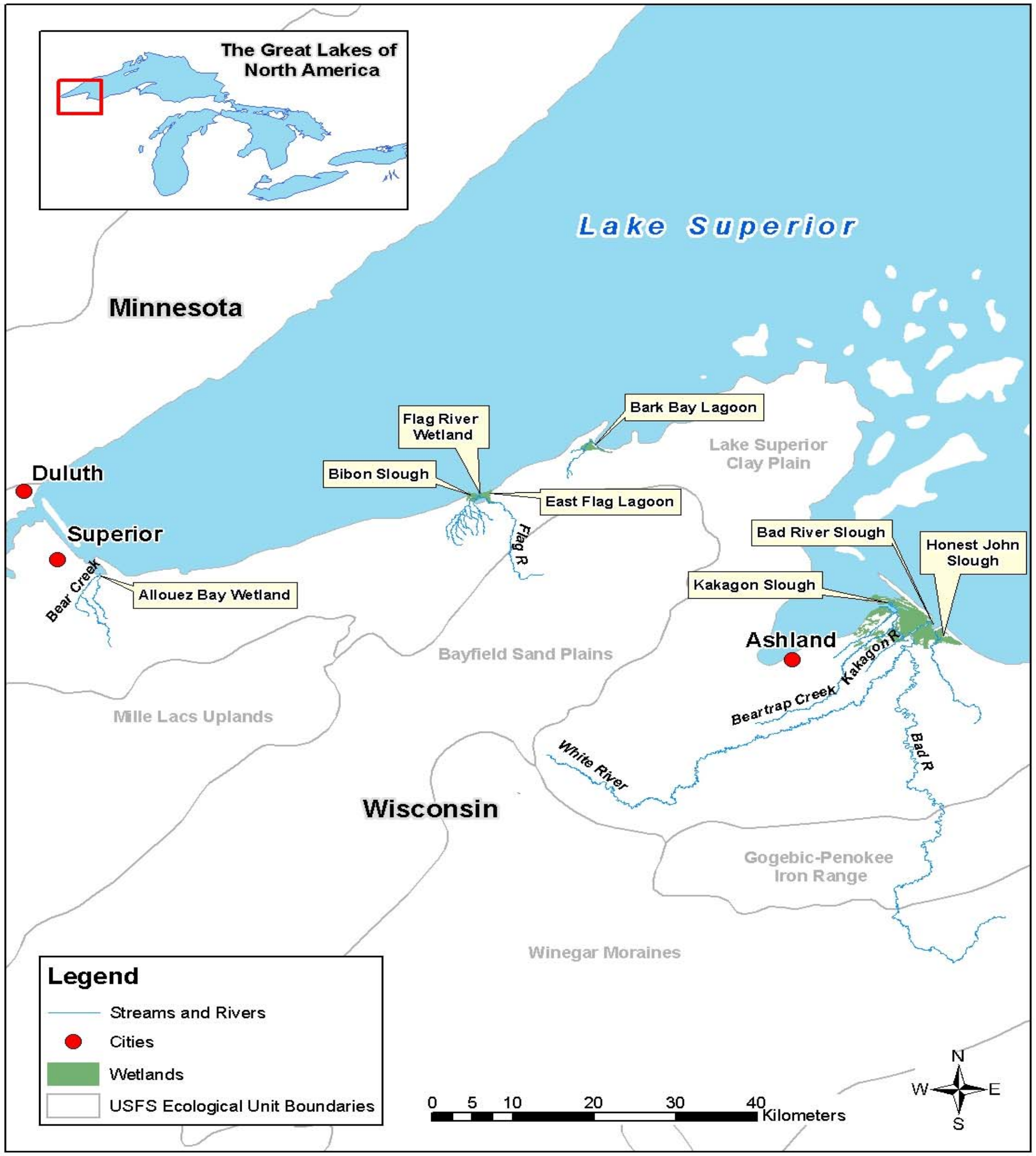

Pagrus auratus (Francis et al. 1992)
1 mm
Image ©
S. Humphreys
Cross section of a snapper, *Pagrus auratus*, showing 9 distinct annual growth rings

Figure 2

Yellow Perch, *Perca flavescens*

Figure 3



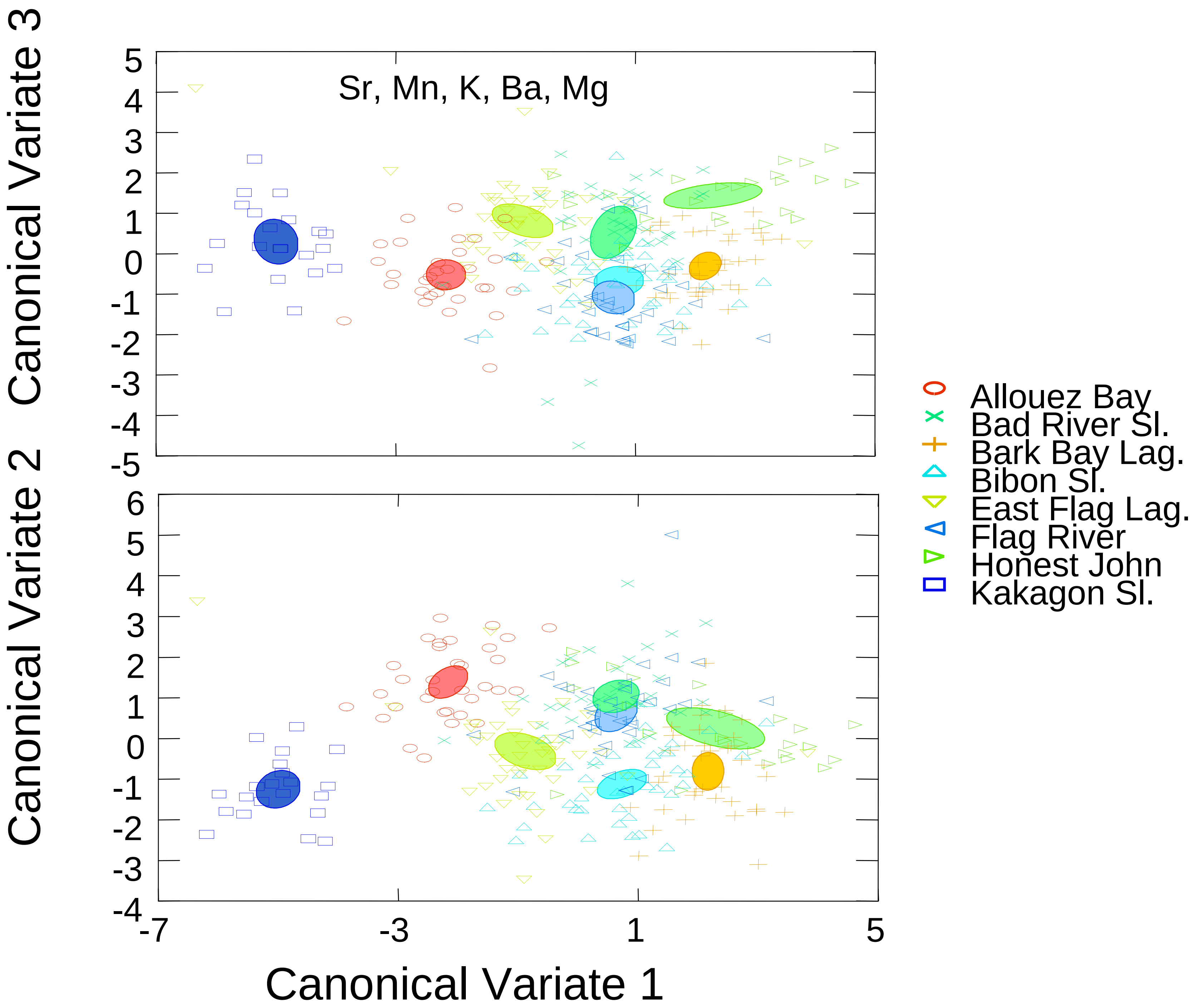
River-influenced

Allouez Bay
Flag River
Bad River
Kakagon Slough

Barrier Beach Lagoons

Bibon Slough
East Flag
Bark Bay
Honest John

Figure 4



Sr, Mn, K, Ba, Mg
Canonical Variate 3
Canonical Variate 2
Canonical Variate 1
5
4
3
2
1
0
-1
-2
-3
-4
-5
6
-7
-3
1
5
Allouez Bay
Bad River Sl.
Bark Bay Lag.
Bibon Sl.
East Flag Lag.
Flag River
Honest John
Kakagon Sl.

Figure 5

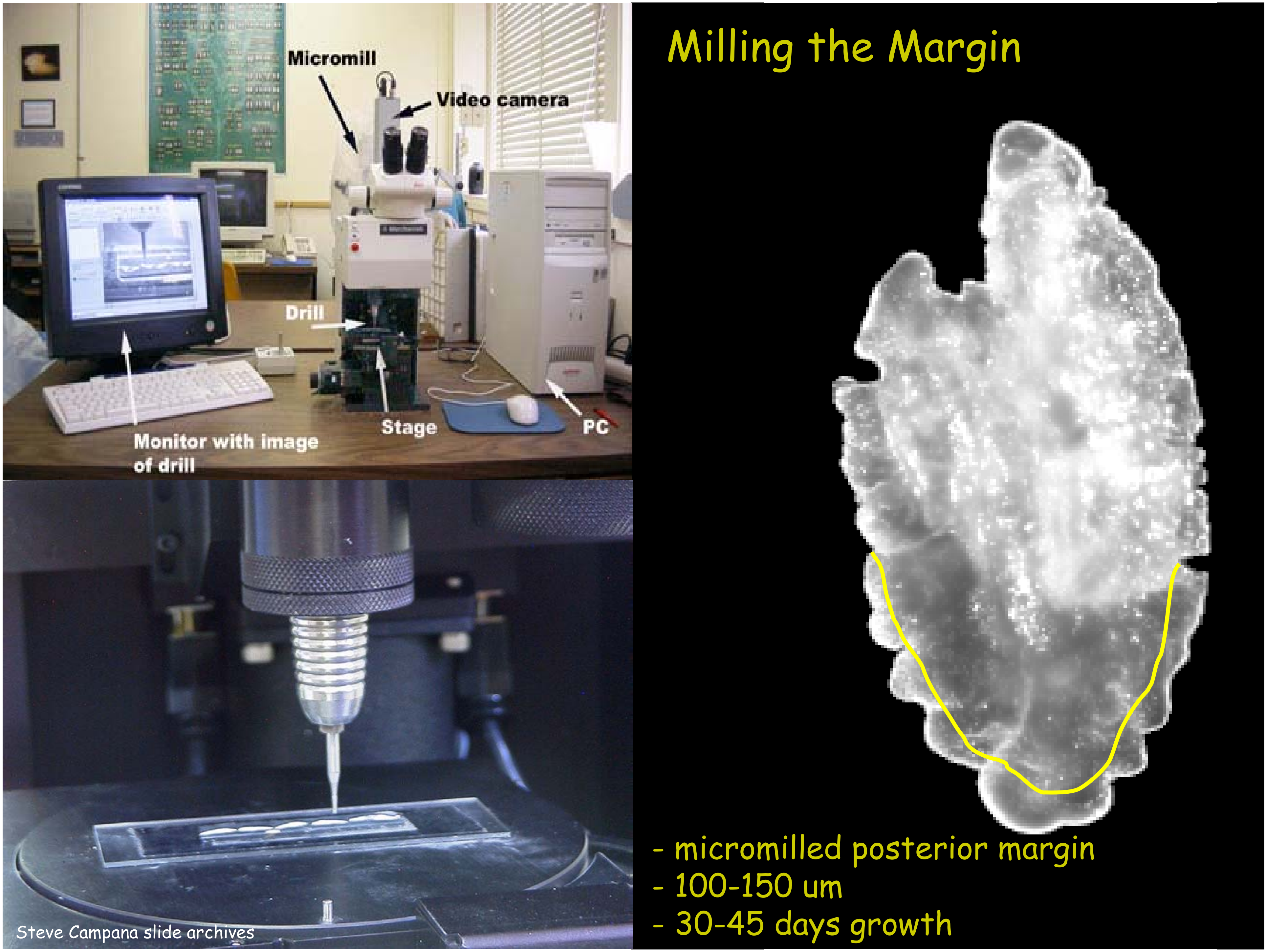

Micromill
Video camera
Drill
Monitor with image of drill
Stage
PC
Steve Campana slide archives
Milling the Margin
- micromilled posterior margin
- 100-150 um
- 30-45 days growth

Figure 6

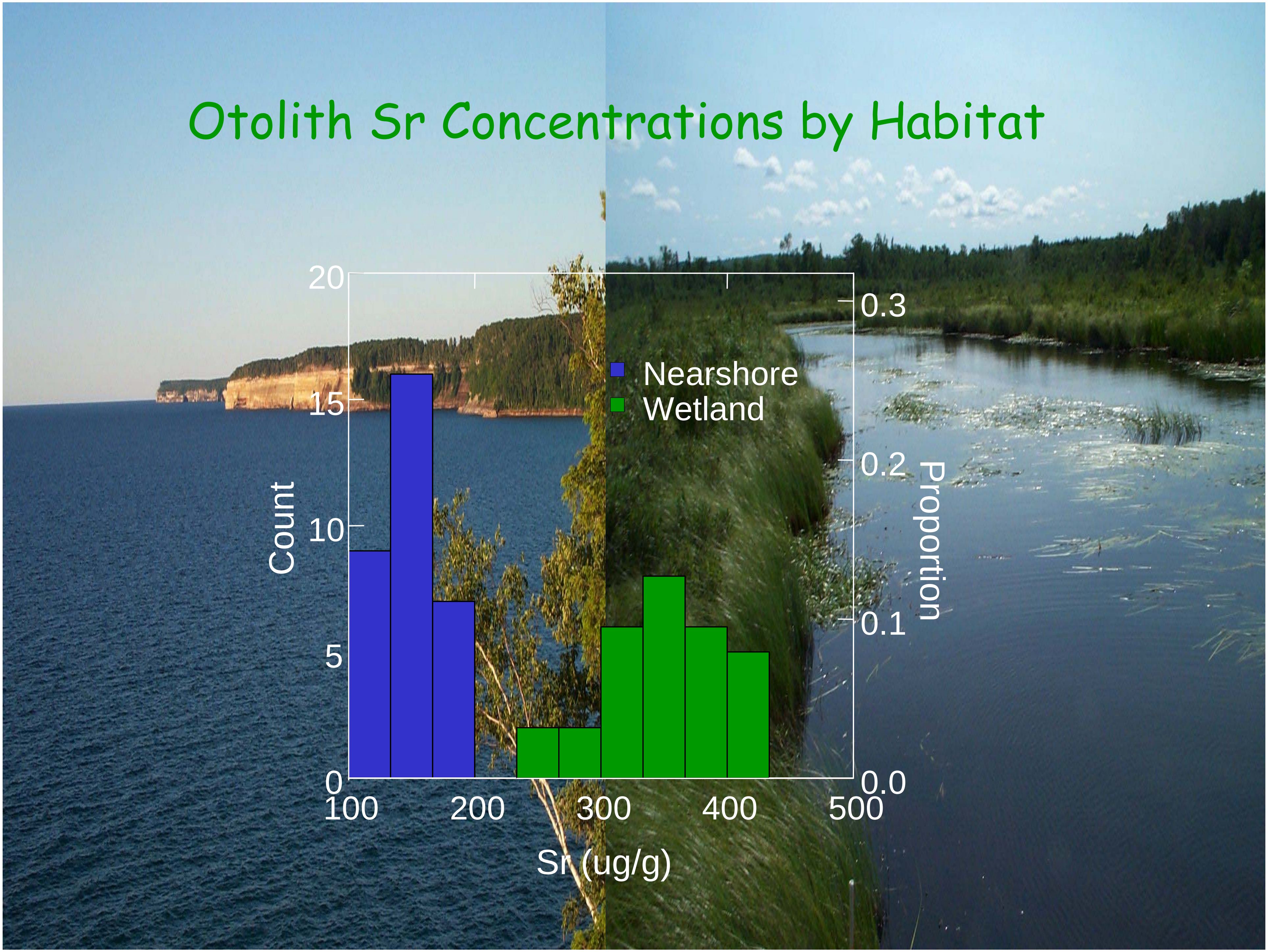

Otolith Sr Concentrations by Habitat
Nearshore
Wetland
Count
Proportion
Sr (ug/g)
0
5
10
15
20
0.0
0.1
0.2
0.3
100
200
300
400
500

Figure 7

Key Products

Brazner JC, Campana SE, and Tanner DK. 2003. Habitat fingerprints for Lake Superior coastal wetlands derived from elemental analysis of yellow perch otoliths. USEPA, Mid-Continent Ecology Division Report, Trans. Am. Fish. Soc. (In review)

Brazner JC, Campana SE, Tanner DK, and Schram ST. 2003. Reconstructing habitat use and wetland nursery origin of yellow perch from Lake Superior using otolith elemental analysis. USEPA, Mid-Continent Ecology Division Report, J Great Lakes Res. (In review)

This is a link to the Otolith Research Laboratory at the Bedford Institute of Oceanography (a collaborator on this project):

http://www.mar.dfo-mpo.gc.ca/science/mfd/otolith/english/home.htm

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